Request from Portugal and Spain to evaluate additional harvest control rules for the Iberian sardine stock in divisions 8.c and 9.a

Advice summary

ICES advises that under the current state of low productivity, modifications to Harvest Control Rule 4 (HCR4) leading to an F_{target} of 0.08 (HCR8) or above will not be precautionary. HCR12 (with F_{low} at 0.046 and F_{target} at 0.064) is consistent with the ICES precautionary approach, with no more than 5% probability of the spawning-stock biomass (B1+) falling below B_{lim} in the long term, while resulting in the highest yield among the precautionary HCRs evaluated.

Request

Following the release of advice on harvest control rules for the Iberian sardine stock in May 2019, Portugal and Spain requested advice on additional HCRs modelled on one of those rules (HCR4; ICES, 2019a). The request was as follows:

Therefore the Spanish and the Portuguese administrations would like to request to ICES to continue the WKSARMP work considering the HCR4 (low productivity) with F_{target} between 0.08 and 0.09 being the long term sustainability ensured with a probability level of 95% of not falling below B_{lim} in the long term.

We request the revised HCR could be the basis of ICES advice on the catch opportunities for the Iberian sardine for 2020 in the bilateral management plan. Therefore and if it is necessary, we would like to ask ICES to present all the management alternatives, including long-term scenarios. We also would like to ask to ICES to update the 2019 advice, on the same basis[1].

It was agreed that in the event a rule was not considered precautionary (F_{target} between 0.08 and 0.09), the evaluation would include simulations to determine the highest precautionary F_{target}. Based on this evaluation, additional catch scenarios would be included in the advice on fishing opportunities for 2020 for sardine in divisions 8.c and 9.a.

Elaboration on the advice

ICES considers that the Iberian sardine stock is in a state of low productivity, which has resulted in low recruitment for the last decade. Under these conditions B_{lim} corresponds to 196 334 tonnes.

ICES evaluated, through full-feedback management strategy evaluations, three harvest control rules similar to HCR4 (ICES, 2019a) but with higher F_{low} and F_{target} reference levels (Figures 1 to 3; HCR8, HCR9, and HCR12). The evaluation included simulation testing to determine the highest F_{target} that would comply with the 5% ICES precautionary criterion for the probability of B1+ being below B_{lim}.

---

[1] ICES indicated that it would not be possible to update the advice on fishing opportunities for 2019 when the request was received.

HCR8


```
i)      B1⁺ ≤ 112 900 tonnes              then F=0
ii)     112 900 < B1⁺ ≤ 196 334 tonnes, then the catch
        a.  shall be fixed at value consistent with F increasing
        b.  linearly from F=0.06 to F=0.08

iii)    B1⁺ > 196 334 tonnes              then F=0.08
```
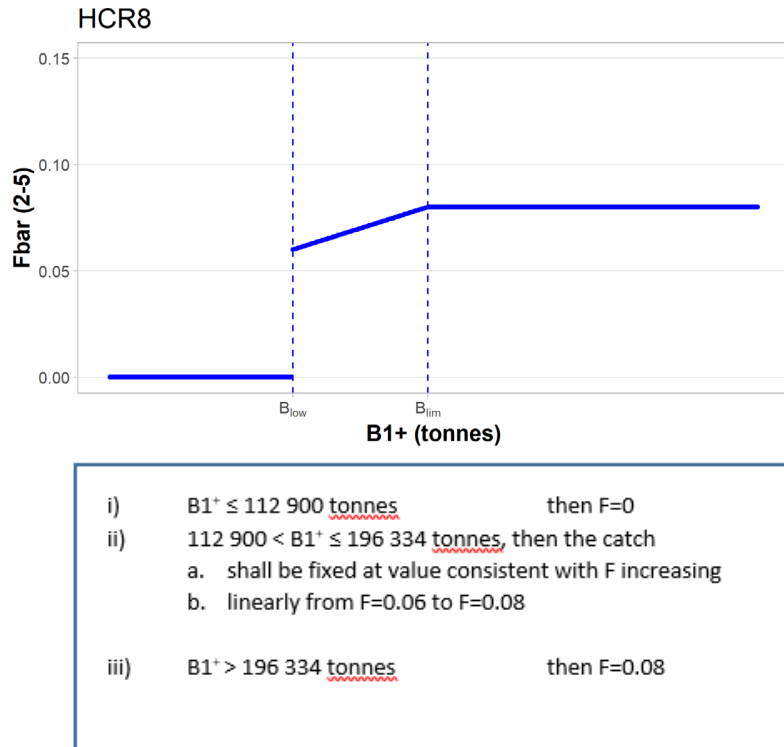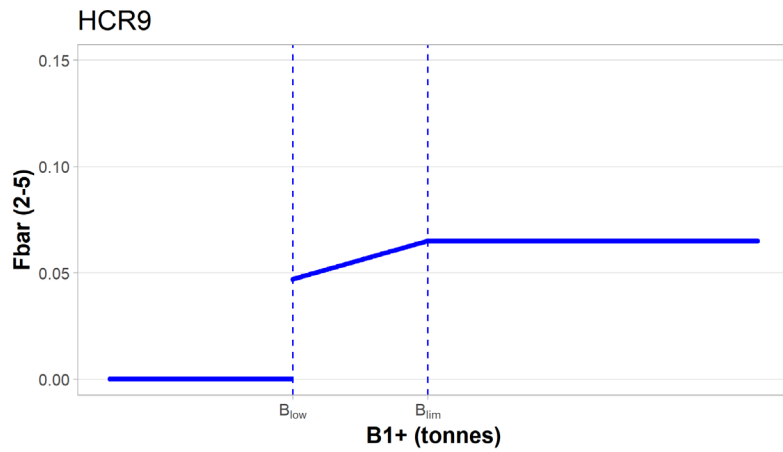
Figure 1   Harvest Control Rule HCR8 with fishing mortality and biomass of fish age 1 and older (B1+) reference levels. The lowest biomass trigger point is B_{low} = 112 900 tonnes and the upper trigger point is B_{lim} = 196 334 tonnes. F increases linearly between the biomass trigger points, from F_{low} = 0.06 to F_{target} = 0.08.

i) $B1^+ \leq 112\,900$ tonnes   then F=0

ii) $112\,900 < B1^+ \leq 196\,334$ tonnes, then the catch
      a.   shall be fixed at value consistent with F increasing
      b.   linearly from F=0.047 to F=0.065

iii) $B1^+ > 196\,334$ tonnes   then F=0.065

Figure 2   Harvest Control Rule HCR9 with fishing mortality and biomass of fish age 1 and older (B1+) reference levels. The lowest biomass trigger point is B_{low} = 112 900 tonnes and the upper trigger point is B_{lim} = 196 334 tonnes. F increases linearly between the biomass trigger points, from F_{low} = 0.047 to F_{target} = 0.065.

HCR12

i) $B1^+ \leq 112\ 900$ tonnes   then F=0

ii) $112\ 900 < B1^+ \leq 196\ 334$ tonnes, then the catch
        shall be fixed at value consistent with F increasing
        linearly from F=0.046 to F=0.064

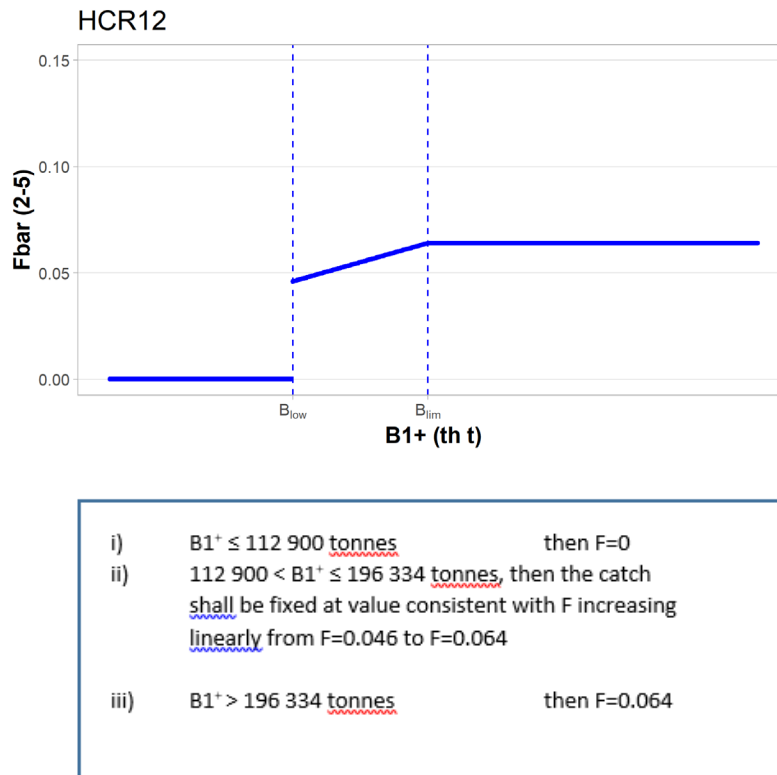iii) $B1^+ > 196\ 334$ tonnes   then F=0.064

Figure 3   Harvest Control Rule HCR12 with fishing mortality and biomass of fish age 1 and older (B1+) reference levels. The lowest biomass trigger point is B_{low} = 112 900 tonnes and the upper trigger point is B_{lim} = 196 334 tonnes. F increases linearly between the biomass trigger points, from F_{low} = 0.046 to F_{target} = 0.064.

Neither HCR8, with F_{low} = 0.06 and F_{target} = 0.08, nor HCR9, with F_{low} = 0.047 and F_{target} = 0.065, would be considered precautionary in the long term since the probability of B1+ being below B_{lim} is estimated to be 13% and 6%, respectively.

HCR12, with F_{low} = 0.046 and F_{target} = 0.064, is considered precautionary since the long-term risk of B1+ being below B_{lim} is less than or equal to 5%. ICES notes that the F target of HCR12 is much larger than the F_{MSY} for this stock. This is due to the form of the HCR which implies an F=0 once SSB falls below B_{low} (112 900 tonnes).

Basis of the advice

Background

On 29 May 2019, ICES provided advice in response to a request from Portugal and Spain to evaluate a management and recovery plan for the Iberian sardine. The advice evaluated several harvest control rules and two of these rules (HCR3 and HCR4) were found to be precautionary in a low productivity regime, which is considered to be the current situation for the stock. These rules were found to have a 1% probability of the spawning-stock biomass (B1+) falling below B_{lim} in the long term. Considering that the risk of the SSB falling below B_{lim} was well below the 5% probability level, which is the threshold accepted by ICES to consider a management and recovery plan as precautionary, Portugal and Spain requested that a modified HCR4 harvest control rule with F_{target} values between 0.08 and 0.09 be investigated to determine if such a rule would be precautionary. It was agreed that in the event the rule was not considered precautionary (F_{target} between 0.08 and 0.09), the evaluation would include simulations to determine the highest precautionary F_{target}. Based on this evaluation, additional catch scenarios would be included in the advice for 2020 for sardine in divisions 8.c and 9.a.

Results and conclusions

The harvest control rule HCR8 (Figure 4, Table 1), with F_{low} = 0.06 and F_{target} = 0.08 as requested, was found to have a greater than 5% probability of falling below B_{lim} in the long term; it is, therefore, not precautionary. The harvest control rules with F_{target} between 0.08 and 0.09 were not tested as requested, as it was apparent that they would not be precautionary. Harvest control rules with a lower F_{target} were evaluated. HCR9 (Figure 5, Table 1), with F_{low} = 0.047 and F_{target} = 0.065, was also found to have a greater than 5% probability of falling below B_{lim} in the long term; this is, again, not precautionary. Out of the other rules evaluated (ICES, 2019b), HCR12 (F_{low} = 0.046 and F_{target} = 0.064; Figure 6, Table 1) was found to be precautionary in the long term while producing the highest yield among all precautionary rules.

With the application of HCR12 the simulations indicated that B1+ could recover to above B_{lim}, with 50% probability by 2021 and with 95% probability by 2031.

Based on the simulations, HCR12 is expected to lead to median catches of 12 805 tonnes in the initial period (2019–2023) and 21 367 tonnes in the final period (2039–2048). However, it should be noted that specific catch advice following HCR12 for a given year will depend on the actual estimate of the stock.

Figure 4   Recruitment (Rec; million individuals), biomass of fish age 1 and older (B1+; thousand tonnes), fishing mortality (F_{2-5}; year), and catch (thousand tonnes) for the assessment period (1978–2017) and during the projected period (2019–2048) for **HCR8** under low productivity. The orange lines represent median values from the assessment period and from the projected period. Shaded areas represent the 90% confidence intervals. The horizontal dashed line in B1+ shows B_{lim} (196 334 tonnes). Vertical long dashed lines separate the historical period from the projected period. The blue and green lines show the results from two of the 1000 simulated iterations, selected randomly.

Figure 5   Recruitment (Rec; million individuals), biomass of fish age 1 and older (B1+; thousand tonnes), fishing mortality (F_{2-5}; year) and catch (thousand tonnes) for the assessment period (1978–2017) and during the projected period (2019–2048) for **HCR9** under low productivity. The orange lines represent median values from the assessment period and from the projected period. Shaded areas represent the 90% confidence intervals. The horizontal dashed line in B1+ shows B_{lim} (196 334 tonnes). Vertical long dashed lines separate the historical period from the projected period. The blue and green lines show the results from two of the 1000 simulated iterations, selected randomly.
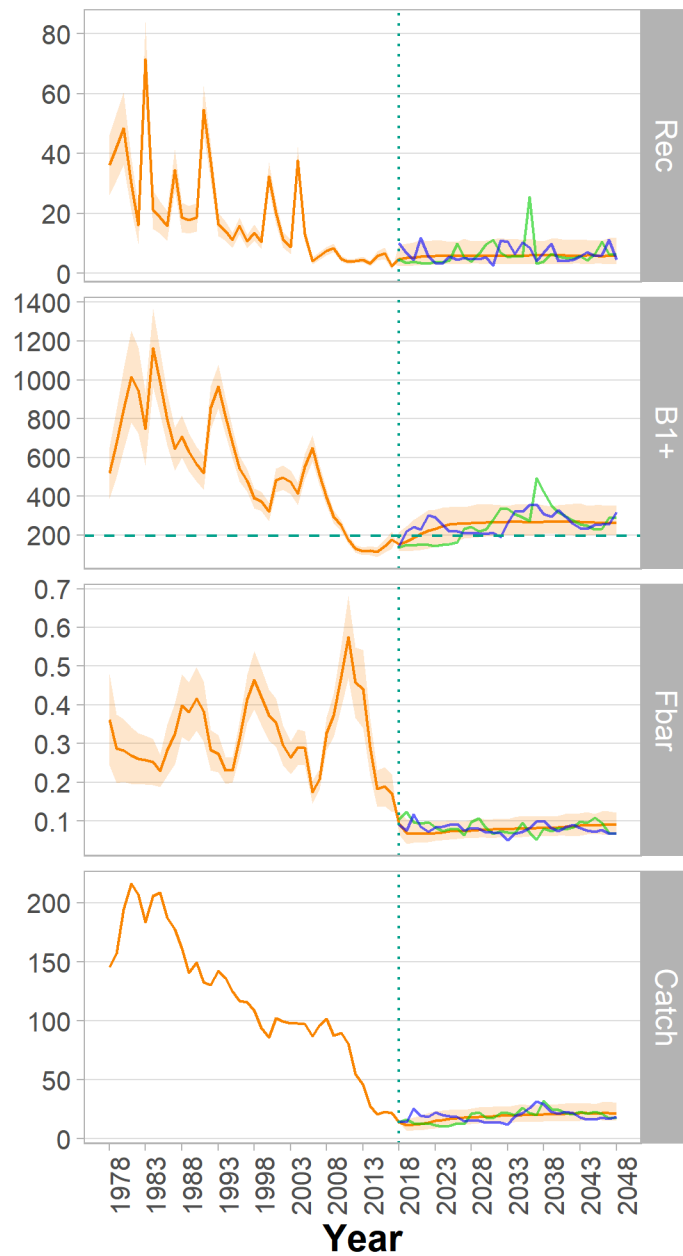
Figure 6 Recruitment (Rec; million individuals), biomass of fish age 1 and older (B1+; thousand tonnes), fishing mortality (F_{2-5}; year), and catch (thousand tonnes) for the assessment period (1978–2017) and during the projected period (2019–2048) for **HCR12** under low productivity. The orange lines represent median values from the assessment period and from the projected period. Shaded areas represent the 90% confidence intervals. The horizontal dashed line in B1+ shows B_{lim} (196 334 tonnes). Vertical long dashed lines separate the historical period from the projected period. The blue and green lines show the results from two of the 1000 simulated iterations, selected randomly.

Table 1   Summary of performance statistics for HCRs 8, 9, and 12. Median (mid-value from the 1000 simulated populations) values are presented.

ICES Advice 2019	Metrics	Period	HCR8	HCR9	HCR12
Indicators	Spawning biomass: B1+ (median, tonnes)	2019–2023	196956	200575	202422
		2019–2028	224612	231347	232265
		2039–2048	252576	265811	26633
	F (median) *	2019–2023	0.085	0.069	0.068
		2019–2028	0.089	0.072	0.071
		2039–2048	0.111	0.089	0.087
	Catch (median, tonnes)	2019–2023	15569	12847	12805
		2019–2028	18188	15289	1517
		2039–2048	25422	21664	21367
	Interannual variability in the catch (absolute, tonnes)	2019–2023	2521	2042	2039
		2019–2028	2684	2175	2141
		2039–2048	3317	2688	2678
	Probability of closure (%)	2019–2023	0	0	0
		2019–2028	0	0	0
		2039–2048	0	0	0
	First year $P(B1+ \geq B_{lim}) > 95\%$	-	Not possible in the examined period (2019–2048)	2032	2031
	first year $P(B1+ \geq B_{lim}) > 50\%$	-		2021	2021	2021
ICES criterion	Risk3 for B_{lim}(%)	2039–2048	13.4	6.1	5

* During periods of low productivity, the current stock assessment model (Stock synthesis) has a tendency to overestimate the biomass which is the basis for the catch short-term forecast component of the MSE. As a consequence, the median of the realized F is higher than the F_{target}.

Methods

The management strategy evaluation (MSE) of the harvest control rules followed the approach and methodology adopted during the Workshop on the Iberian Sardine Management and Recovery Plan (WKSARMP; ICES, 2019b), undertaken using FLBEIA (Bio-Economic Impact Assessment using FLR; García *et al.*, 2017). All catch rules were simulation tested considering a permanent low productivity for the Iberian sardine and, accordingly, adopting a B_{lim} of 196 334 tonnes.

The request specified two F_{target} reference levels, 0.08 and 0.09. However, since the evaluation of the harvest control with F_{target} of 0.08 (HCR8) resulted in a 13% long-term risk of B1+ being below B_{lim}, several other harvest control rules scaling down both F_{low} and F_{target} were simulation tested.

Sources and references

García, D., Sánchez, S., Prellezo, R., Urtizberea, A., and Andrés, M. 2017. FLBEIA: A simulation model to conduct Bio-Economic evaluation of fisheries management strategies. SoftwareX, 6: 141–147. https://doi.org/10.1016/j.softx.2017.06.001.

ICES. 2019a. Request from Portugal and Spain to evaluate a management and recovery plan for the Iberian sardine stock (divisions 8.c and 9.a). *In* Report of the ICES Advisory Committee, 2019. ICES Advice 2019, sr.2019.10. 9 pp. https://doi.org/10.17895/ices.advice.5275.

ICES. 2019b. Workshop on the Iberian Sardine Management and Recovery Plan (WKSARMP). ICES Scientific Reports, 1:18. 154 pp. http://doi.org/10.17895/ices.pub.5251.